Update on Flex Cable Development at UNM

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Introduction

- UNM is developing two different flex prototypes:
  - High speed data transmission flex
  - Stave flex

High Speed Data Transmission Flex

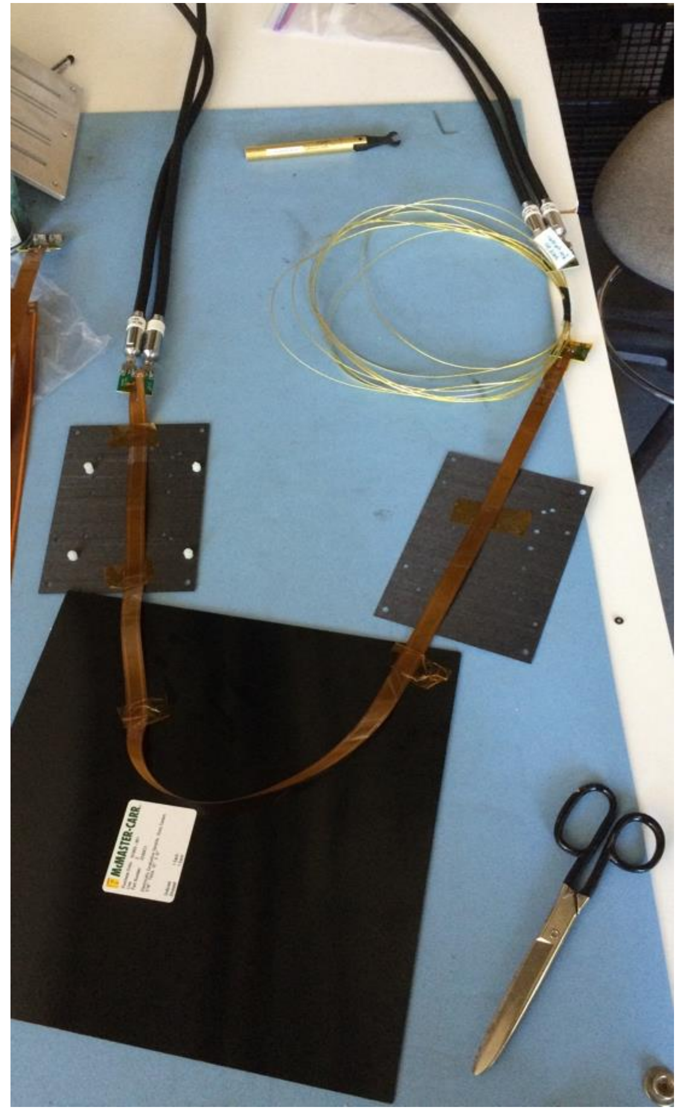
- Previously, we have presented results on 1.0 m long differential pair micro strip design including:
  - Use of different Dupont Kapton materials (AP, TK)
  - Attenuation vs frequency results
  - BER test results up to 5 Gbps effective bandwidth
  - % Radiation Length X_0 = 0.016% smeared over 20.0 mm
  - Irradiation results testing for radiation hardness to 2×10^{16} neq/cm^2 for proton and neutron and 500 MRad for gamma.

High Speed Data Transmission Flex

- Recent work:
  - I travelled to LBNL (23-25 June) to perform VNA S-parameter measurements.
  - With the S-parameters, Veronica Wallangen (LBNL) performed simulations using the UNM flex attached to the SLAC 6.0 m 30 awg twinax.
    - She provided impulse response and eye diagrams using the measured S-parameters.
- I also measured the effect of conductive carbon fiber when in close proximity to the flex.

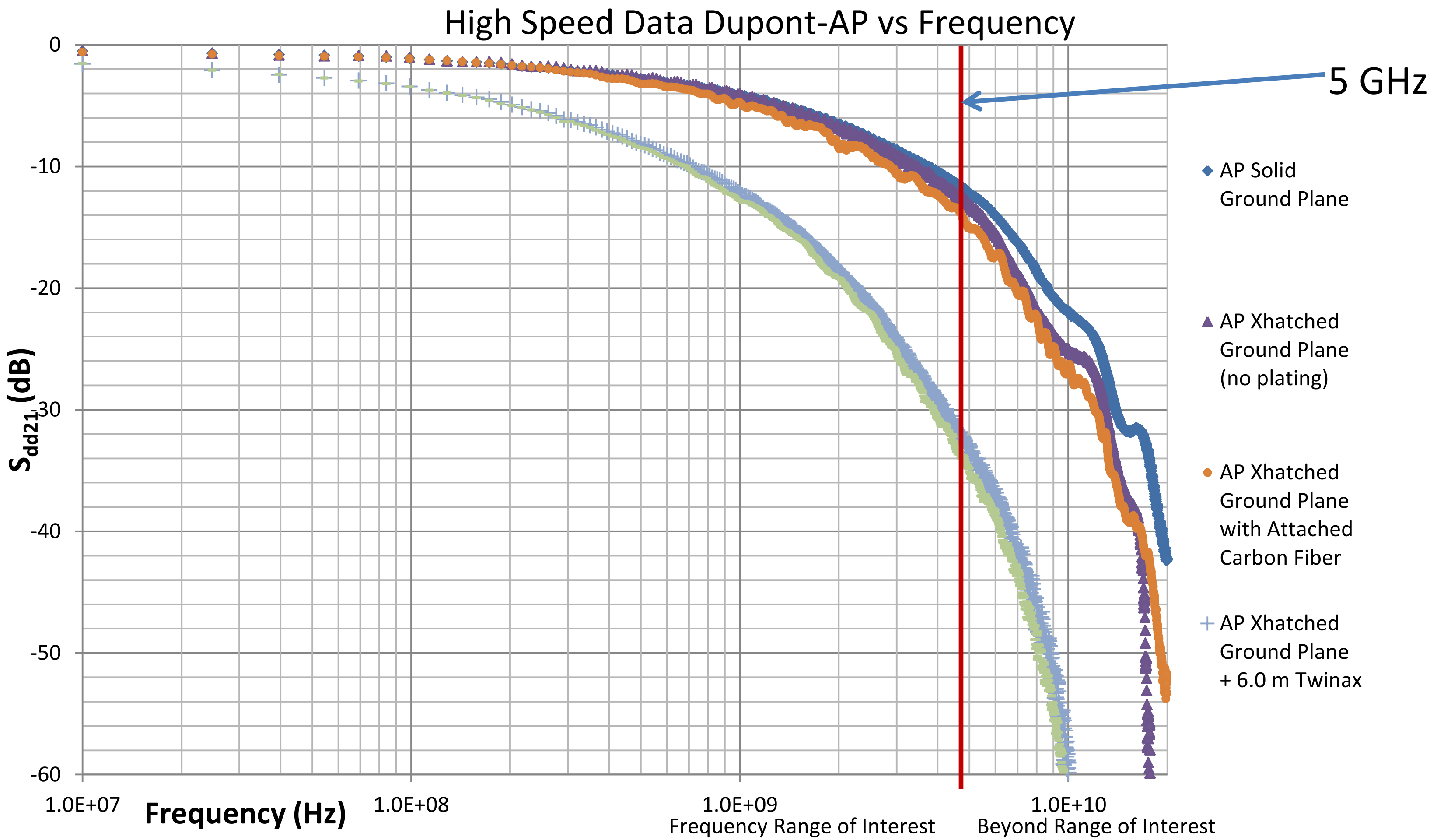
High Speed Data Transmission Flex

VNA Setup for 1.0 m Flex



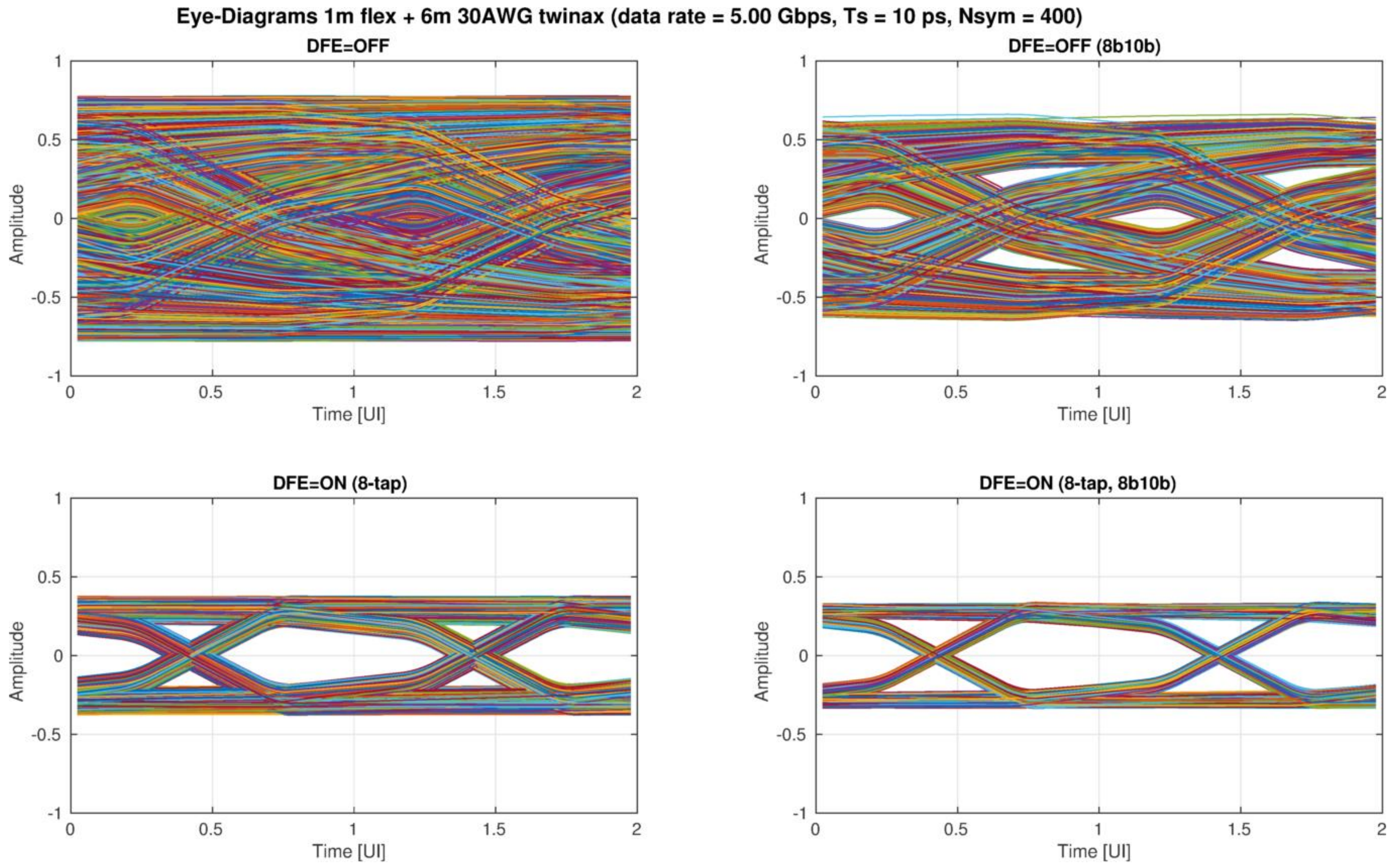
VNA Setup for 1.0 m Flex + 6.0 m Twinax + Attached Carbon

High Speed Data Transmission Flex



- This plot shows S_{dd21} results on five variations of the 1.0 m AP flex. There is no noticeable difference in attenuation up to the frequency range of interest (5 GHz) for the 1.0 m cross hatch and solid ground plane flex. Additionally adding carbon fiber has a negligible effect.
- The flex + twinax result shows considerable attenuation > 1 GHz, how this would affect a BER test is the subject Veronica's study.

High Speed Data Transmission Flex



- Veronica's simulation results use S-parameters to simulate a 5 Gbps transmission on a 6.0 m twinax + 1.0 m flex with cross hatched ground plane: raw, 8b10b encoding only, DFE (8-taps) and, DFE + 8b10b encoding
- Wider openings in the eye diagrams indicate 5 Gbps data transmission is possible with little to no errors.

High Speed Data Transmission Flex

- Future plans:
  - I am scheduled to travel to UCSC from August 15-17 to perform BER tests.
  - I will do the BER test on the flex + twinax hybrid.
- We are prototyping optimized ground plane cross hatching for:
  - Stripline geometry to fully shield data lines.
  - Thinner cross hatch on microstrip design to reduce X_0.

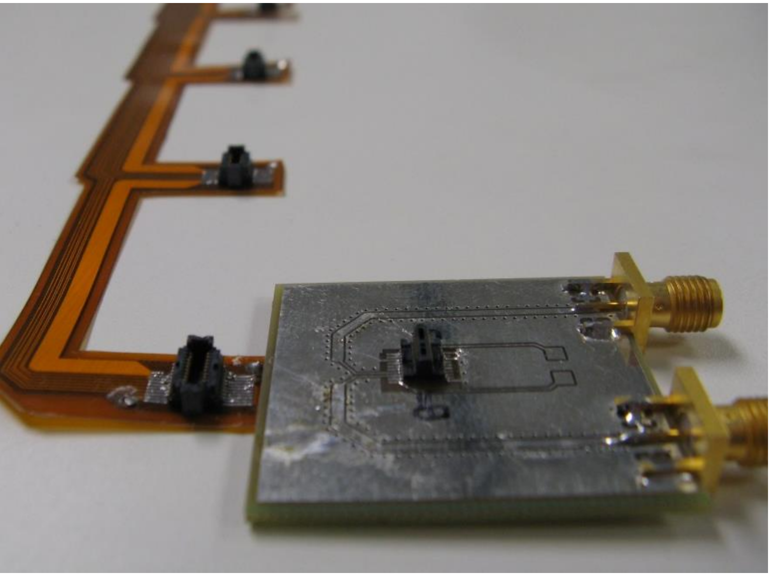
Stave Flex

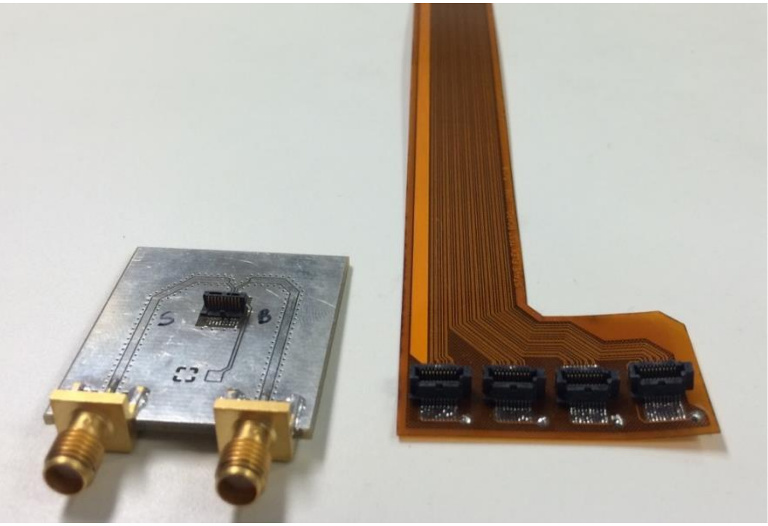
- Previously we presented a CAD drawing of the stave flex design, which will provide serial power, bias voltage, a temperature monitor, module control and high speed data transmission.
- Recent Work includes:
  - Fabrication of stave flex prototype #1
  - Impedance and attenuation vs frequency measurements
  - S parameter measurements.

Stave Flex

- Prototype stave flex for layers 3,4, and 5 with estimated max data rate of ~4.3 Gbps per chip.
- The stave flex was fabricated with the following features:
  - 6 wings for module connections at lengths from 0.75 m to 1.0 m
  - LV power, HV bias voltage, a temperature monitor, module control and high speed data transmission
  - High speed data and control lines have 100 Ω differential impedance
  - LV power accommodates serial the powering scheme
  - A polyimide material with a thinner dielectric than the high speed data cable which used the Dupont Kapton (AP) material. The thinner dielectric means narrow traces for an equivalent 100 Ω cable, to reduce radiation length.

Stave Flex

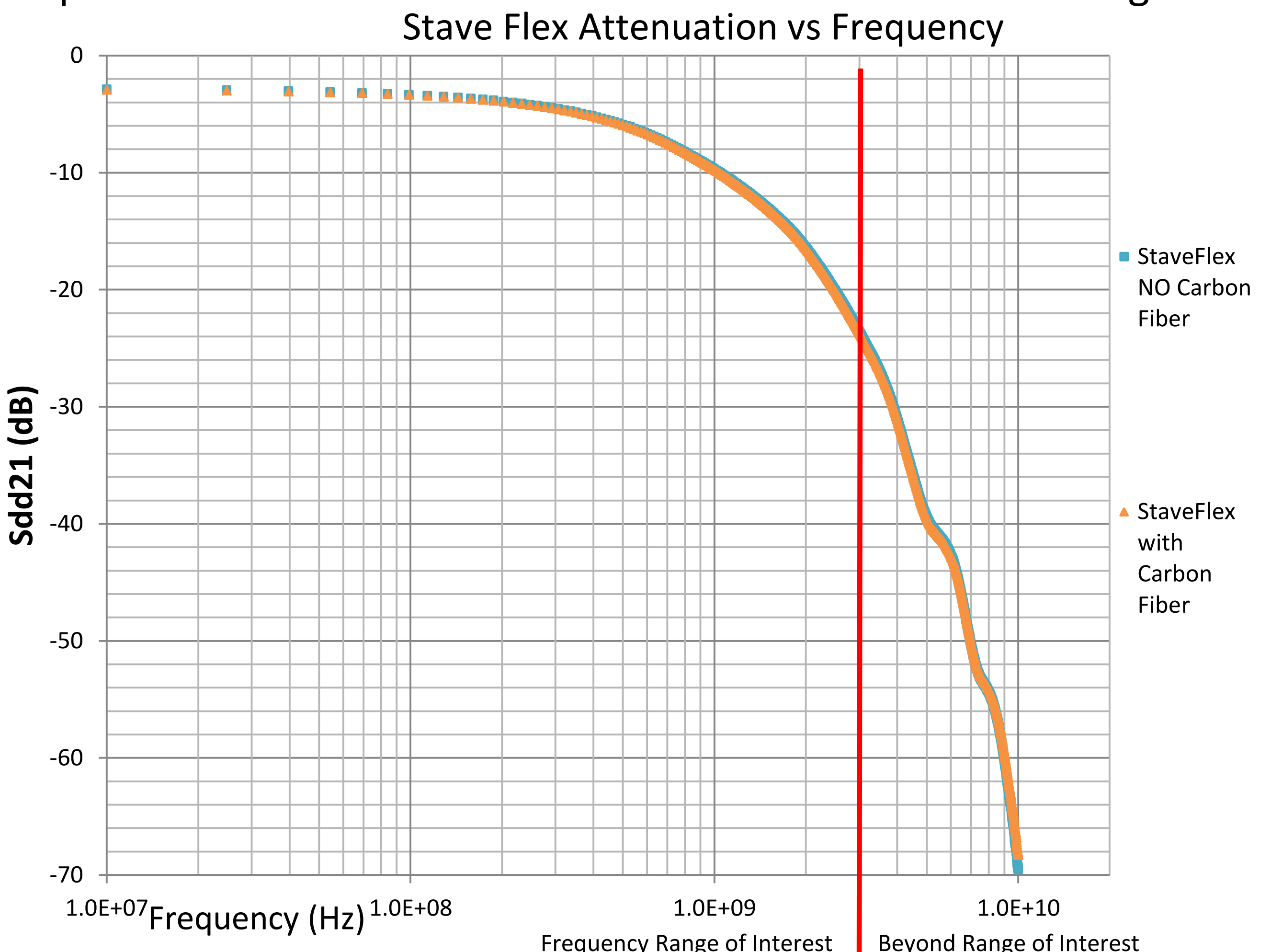


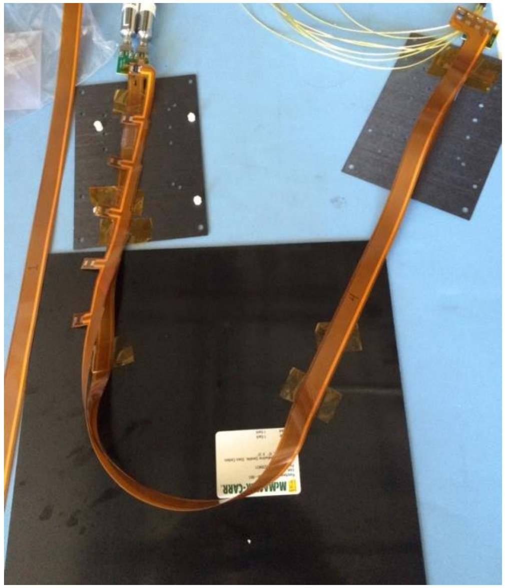


- The stave flex is terminated with Samtec SS5 and ST5 connectors. These connectors have a 1.5 A current rating per pin and are rated to 28 Gbps. Additionally they have 100 Ω differential impedance.
- The PC boards are adaptors to SMA coax connectors to measure the differential data lines. Additionally the adaptors have pads in line with the LV serial power to mimic the power draw of the chip.

Stave Flex

S-parameter measurements done at LBNL on the 1.0 m wing





There is no noticeable difference in attenuation up to the frequency range of interest (5 GHz) when comparing result with and without carbon fiber attached.

Stave Flex

- Future plans:
  - We will be doing neutron irradiations at Sandia Labs ACRR (Albuquerque) from August 10-12 to verify the radiation hardness of the new polyimide material. Our target fluence is $5x10^{15}$ 1-MeV neutron/cm^2 (sufficient for layers 3,4,5).
  - The following week, 15-17th, I will be performing BER tests at UCSC on the all of the stave flex data lines (6 in total).
  - On November 18th-20th we will irradiate the stave flex with 800 MeV protons at the LANSCE facility in Los Alamos.

Acknowledgments

- Thanks very much to the following people:
  - Maurice Garcia-Sciveres and Veronica Wallangen for hosting my visit to LBNL to perform VNA measurements.
  - Phillipe Grenier, Su Dong, and Martin Kocian at SLAC for sending the various twinax cable samples.
  - Vitaliy Fadeyev, Jason Nielsen, and Mike Hance at UCSC for hosting my visits to UCSC to perform BERT measurements.